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Variation of Windspeed with Canopy Cover within a Lodgepole Pine Stand

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The linear correlation computed for 22 points in a lodgepole pine canopy suggests independence between the point-to-point variations in speed at any level and variations of total canopy cover.

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Previous Work

A recent study of the variation of windspeeds from point to point in an even-aged pine stand (Bergen 1971) indicated strong variations in speed—at the same level and at the same time—between locations only a few meters apart. These measurements were made at six levels and at points nearly equidistant from the nearest four stems; thus they should reflect not so much the lower speeds to be expected within tree crowns as compared to the space between trees, as the random variations in tree spacing and crown densities.

The estimated specific variation—that is, the variance divided by the average—and averages for the 22 windspeed profiles scaled by the speed at 11 m height are shown in table 1. The specific variation ranges from 24 to 45 percent, with the lowest values at treetop level and the highest value at approximately the location of the average maximum foliage weight of the tree crown, as established by foliage weight measurements.[2] The specific variation of the crown foliage weight at each level, found from the dissection of five tree crowns, is shown in the last column of the table. There seems to be no relation between the height trends of windspeed and foliage weight variability, although because of the small sample for the latter, no firm comparison can be made.

Convincing arguments have been made that the local variations in windspeed should be closely correlated with variations of the local canopy cover, or equivalently the skyview factor F, defined as the fraction of the field of view looking upward from below the canopy which is unobstructed by foliage. The outlines of the analysis can be found in Isobe's analysis for windspeeds in crop canopies (Isobe 1967). This concept seemed to be borne out by the relatively high windspeeds found at every level in the largest natural opening (about 5 m in diameter) in the stand (Bergen 1971), and seemed worth investigating in view of the value such a correlation would have in designing stratified sampling schemes to establish space average wind profiles in natural stands.

Current Analysis

This Note reports essentially negative results—a lack of correlation either between windspeed and the total view factor, or between windspeed and a modified view factor designed to allow for the orientation of the local canopy to the wind direction above the canopy.

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[2]*Gary, Howard L. Crown structure, and vertical distribution of biomass in a lodgepole pine stand. (Manuscript in preparation at Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.)*

Table 1.--Linear correlations between windspeed and canopy cover indices with associated statistics

Height (Meters)	Scaled speed $\bar{U}$	Specific variation of speed S	Speed correlation with F	Estimated upper limit of r for stand	Estimated lower limit of r for stand	Speed correlation with L	Specific variation of foliage weight
1.07	0.58	0.33	-0.28	+0.2	-0.6	-0.05	0.00
2.50	.76	.30	+ .26	+ .6	- .1	+ .31	.00
4.00	.65	.30	+ .15	- .4	- .2	+ .07	.13
5.60	.66	.45	+ .01	- .4	+ .4	- .32	.05
7.00	.49	.30	+ .18	+ .4	- .2	+ .13	.08
8.50	.74	.24	+ .37	+ .6	.0	- .04	.09

The value of F was computed for each of the 22 profile locations from a vertical photograph of the canopy, taken from a height of 50 cm above the profile base with a 45° aperture lens. The field of view at the height of the foliage maximum was a square 13 m on a side. This level was also the height of the maximum horizontal branch extension as estimated from the five tree samples.

The fraction of the field of view occupied by the sky was calculated as the average fraction of seven circular sectors filling the field of view and divided into 10° segments (fig. 1). A segment was counted totally clear or obscured, depending on whether more than half its area was occupied by foliage images.

The distribution of F for 40 points between trees in the stand, including those for which windspeeds were measured, showed an approximately normal distribution; F averaged 66 percent and ranged from 51 to 100 percent.

The sample used for the calculations was restricted to those 22 points where no single low-lying branches seemed to dominate the field of view, and where complete six-level windspeed profiles were available.

Results

As may be seen in the table, none of the computed correlations are significant, except insofar as the results rule out any close association between F and the local speed at any level.[3]

The F factor was then modified so that the orientation of the local canopies to the above-canopy wind direction could be considered. This modified F was the average length of the unobscured central fifth of the field of view measured along the above-canopy wind direction, noted as L on the table. The factor L is shown to have a specific variance of 67 percent and a linear correlation of 0.57 with F over the 40 grid points. In general, L shows no closer association with the local windspeed than F, as is evident from the last three columns in the table.

Conclusions

The results suggest two significant conclusions.

1. It appears likely either that the close association of foliage density and view factor

[3] *This statement is valid if the use of Fisher's Z (Panofsky and Brier 1958) for estimating the 90 percent confidence interval for some hypothetical large parent distribution, such as a forest, may be accepted. For a severely truncated distribution, such as that to be expected for the speed, such a confidence interval would be overconservative.*

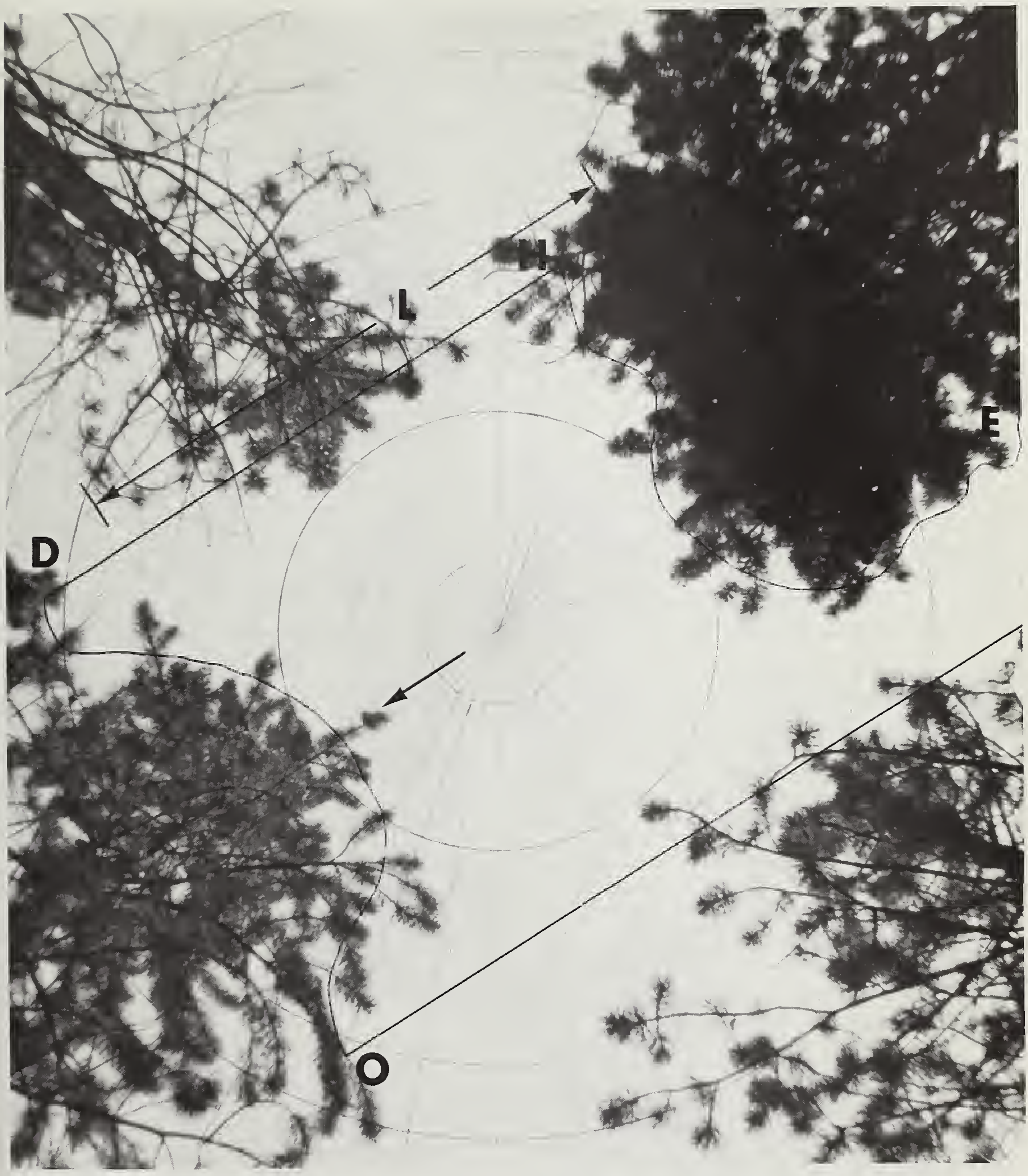

Figure 1.—Typical vertical canopy photograph with superimposed grid. The arrow is in the direction of the wind above the canopy. The area HDOE is used to compute the average apparent open fetch length (L).

observed when comparing separate stands is not paralleled by measurements within a stand, or that the local airflow irregularities reflect canopy irregularities of a much smaller or of a larger scale than that involved in the average canopy density and arrangement in space of the nearest four trees. That is, the calculation may be comparing the wake of a branch with the shadow of the crown.

2. Energy balance computations using the average canopy cover and windspeed in a pine stand are probably not in any appreciable error due to the neglect of the interaction between point-to-point variations in these variables.

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